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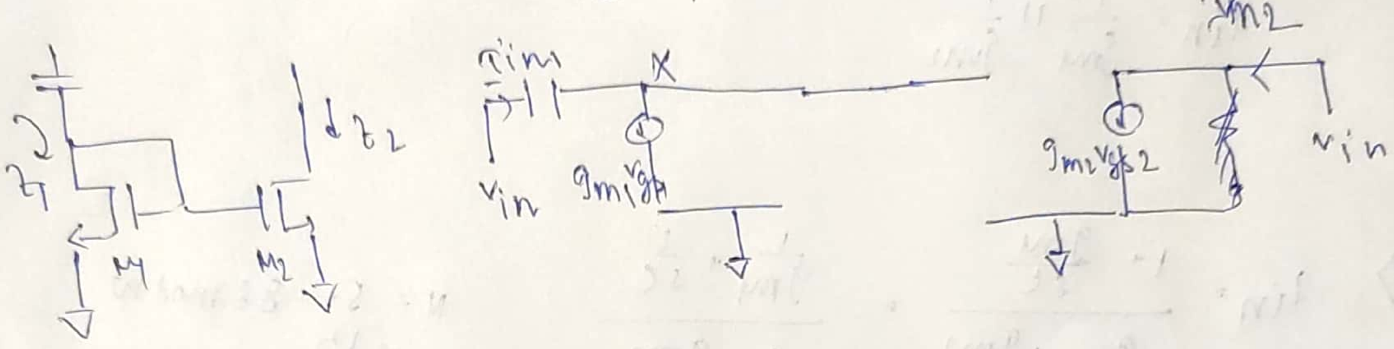
4.

$g_m = \mu_n C_{ox} \frac{W}{L} V_{ov}$

i) ~~Both~~ both circuits V_{ov} is same if we assume V_{th} is same for both

$$\frac{g_{m1}}{g_{m2}} = \frac{(W/L)_1}{(W/L)_2} = \frac{(W/L)_1}{N\,(W/L)_1} = \frac{1}{N}$$

ii)



$Z_1 = \frac{1}{g_{m1}} \| \infty$

$Z_2 = \infty$

The total current is

$I_{in} = I_{in1} + I_{in2}$

$I_{in2} = g_{m2}V_{gs2}$ $\quad I_{in1} = g_{m1}V_{gs1}$

$V_x = V_{in} - I_{in1} \times \frac{1}{sC}$ $\quad V_{gs1} = V_{gs2} = V_x$

or $V_x = V_{in} - \frac{I_{in1}}{sC}$

or $V_x = V_{in} - \frac{g_{m1}V_{gs1}}{sC}$

$\therefore I_{in2} = g_{m2}V_x$

$I_{in1} = g_{m1}V_x$

$V_x = V_{in} - \frac{g_{m1}V_x}{sC}$

or $V_{in} = V_x\left(1 + \frac{g_{m1}}{sC}\right)$

or $V_x = \frac{V_{in}}{1 + \frac{g_{m1}}{sC}}$

$\therefore I_{in} = (g_{m1} + g_{m2})V_x$

or $I_{in} = \frac{(g_{m1} + g_{m2})V_{in}}{1 + \frac{g_{m1}}{sC}}$

or $\frac{V_{in}}{I_{in}} = Z_{in} = \frac{1 + \frac{g_{m1}}{sC}}{g_{m1} + g_{m2}}$

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iii) $z_{in} = \frac{1}{g_{m1}+g_{m2}} + \frac{g_{m1}}{g_{m1}+g_{m2}} \frac{1}{sC}$

$= \frac{1}{g_{m1}} \parallel \frac{1}{g_{m2}} \left(1 + \frac{g_{m1}}{sC}\right)$

If capacitance was infinite it would just be short and we expected

$z_{in} = \frac{1}{g_{m1}} \parallel \frac{1}{g_{m2}}$

iv) $z_{in} = \frac{1 + \frac{g_{m1}}{sC}}{g_{m1}+g_{m2}} = \frac{\frac{1}{g_{m1}} + \frac{1}{sC}}{1 + \frac{g_{m2}}{g_{m1}}}$ $N = 5 + 88 \bmod 20$
$= 13$

$= \frac{\frac{1}{g_{m1}} + \frac{1}{sC}}{N+1} = \frac{1}{14}\left(\frac{1}{g_{m1}} + \frac{1}{sC}\right)$

Capacitance is extremely small so

$\frac{1}{g_{m1}} << \frac{1}{sC}$

$z_{in} = \frac{1}{14sC} = \frac{1}{14s \times 10^{-12}} = \frac{10^{12}}{14s} \Omega$

$= \frac{10^9}{14s} k\Omega = \frac{10^6}{14s} M\Omega$